Stochastic optimal control of heart rate during tradmill exercise

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Automated exercise testing systems have become increasingly important. This may lead to an improvement in developing training protocols. The aim of this study was to develop a new computer controlled treadmill system with stochastic optimal control theory, which can automatically set the treadmill speed to control the heart rate of the subject according to a preset target heart rate profile.

Methods

12 healthy,able-bodied male subjects each did three separate, 35-min tests on a treadmill. The first test used the pole assignment control theory, which was used in the previous work of IRPT. The aim of the first test was as a reference to compare with other two tests. The second and third tests utilized the stochastic optimal control theory with different weighting elements ρ.

Results

There were no significant differences in the overall mean RMSE (2.12 vs.2.20 vs 2.22 bpm, p = 0.57) between the three tests. But the mean control signal power of test 2 (22.63*10-4m^2/s^2) was much lower (significant differences, p= 5*10^{-9}) than test 1 (78.51*$10^{-4}m^2/s^2$) and test 3 (62.48*$10^{-4}m^2/s^2$).

Conclusions

The stochastic optimal control method provides a better and more convenient way to tune the parameters of heart rate control system than the pole assignment method. Further investigations should be done, with the aim to look for a much better control performance with other weighting elements ρ.

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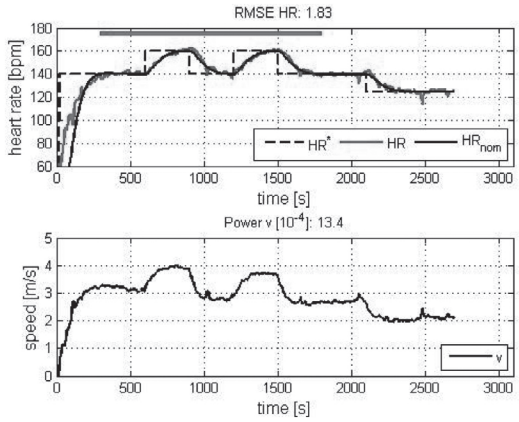
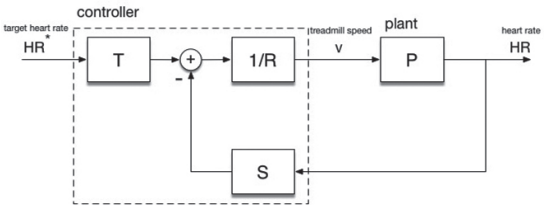


Results with the stochastic optimal controller



Closed-loop structure for feedback control of heart rate.